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Evaluate polymer degree of conversion of bulk-fill composite restoration

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Abstract:
Background: *This study aimed to measure degree of conversion of bulk-fill composite*
Materials and Methods: *Ten samples of each group of material Three of group are bulk fill composite SonicFill , Surefill SDR & Tetric EvoCeram and one with incremental fill universal posterior composite G-aenial posterior GC . The specimens were prepared for each group following ISO standard 4049 (degree of conversion). All the available data were obtained the mean and standard deviation for each sample were collected and it analyzed with analysis of variance one-way ANOVA and LSD test at p ≥ 0.05 level of confidence. Using utilizing SPSS statistical software*
Results: *the result highly significant different between groups of bulk fill (Tetric EvoCeram flow, Sonic Fill & SDR) in comparison with incremental- Fill GC flow composite .also comparison between different bulk fill composite showed highly significant different between Sonic fill and other types of bulk fill composite(Tetric EvoCeram and SDR) , while there no significant different between Tetric EvoCeram and SDR composite resin*
Conclusions: *bulk- fill composite (single layer) can be an alternative for posterior incremental layers restoration and sonic fill composite showed high degree of conversion*
Key words: *bulk-fill, degree of conversion , sonic- fill restoration*

I. Introduction

The physical, mechanical and aesthetic properties and the clinical behavior of composites depend on properties of three chemically-different materials: the organic matrix or organic phase; the inorganic filler or disperse phase; and an organosilane or coupling agent to bond the filler to the organic resin.[1] .The organic matrix of composite resins is made up, in essence, of a system of mono-, di- or tri-functional monomers; a free radical polymerization initiation system, which in photocurable composite resins is an alpha diketone (camphoroquinone) used in combination with a tertiary aliphatic amine reducing agent [2]. Because this resin is highly viscose, to facilitate the manufacturing process and clinical handling it is diluted with other low-viscosity monomers (low molecular weight) which are considered viscosity controllers, such as bisphenol A dimethacrylate (Bis-DMA), ethylene glycol dimethacrylate (EGDMA), triethylene glycol dimethacrylate (TEGDMA), methyl methacrylate (MMA) or urethane dimethacrylate (UDMA)[3,4] . the main dental composite manufacturers currently still concentrate on the traditional systems, mostly adding a Bis-GMA/TEGDMA monomer or a Bis-GMA/UEDMA/TEGDMA combination to the organic matrix.

Monomer conversion doesn't completed 100% to converted into polymer which give unsaturated free monomer (unreacted monomer). the number of double carbon links(C = C)present in the monomer which are converted into single link (C - C)to give polymer chains in polymerization process this process called degree of conversion [5,6] resin composite started polymerization reaction by absorbing ultraviolet light in range of wave of length around 400- 600 nm ;aliphatic amine started reaction to produce free radicals . unfortunately ,the dimethacrylate exhibit unsaturated free monomer in the final product [7,8] there are several factors that affect the degree of conversion like; power density [9],light source [8],irradiatio time [9], light -tip size[9] ,wave length[10],chemistry of organic matrix formulation [7,9] photo-activation method [11]distribution and quantity of inorganic filler [12] and the color of composite resin [13]

the physical and mechanical properties of dental composite are directly affect by degree of conversion [14]lower DC lead to Undesirable Consequences of Inadequate properties ; Reduced bond strengths , Increased breakdown at margins , Decreased biocompatibility Potentially increased DNA damage due to leachates , Increased bacterial colonization of resin, greater discoloration and degradation[15] and this give restoration with poor wear resistant and color stability , less bonding adhesion and marginal microleakage [16,17]. Evaluate for monomer-to-polymer conversion using a Fourier transform infrared spectrophotometer (FTIR) or using attenuated total reflectance (ATR) detector .

Recently a new bulk fill types of composite introduced with depth of cure about 4mm one layer, Advantages of "New Class" of materials Saves Time, Easier Better adaptation to tooth, Reduce chance for air entrapment , Better conformity to cavity walls , Better marginal integrity ,Less shrinkage stress Greater Depth of cure 4-5 mm , and better degree of conversion [18,19,20] . the introduction of flowable composites provides

expanded options for restorative dentistry. developed for use in bulk restorations [21,22].differents types of bulk fill materials likes; SonicFill (Kerr) , Surefill SDR Flow (Dentsply) , Caulk Filtek Bulk Fill (3M ESPE) ,Venus Bulk Fill (Heraeus Kulzer), X-tra base and X-tra Fil (VOCO), Tetric EvoCeram Bulk Fill (Ivoclar Vivadent) and QuiXfil (Denstply Caulk). the aim of this study was to investigate the degree of conversion of bulk-fill composite (SonicFill , Surefill SDR & Tetric EvoCeram) and compare with incremental universal posterior composite G-aenial posterior GC , Japan .

II. Materials and methods ;

2 .1 Samples prepare : Four group each group has Ten samples of each material prepared by the same investigator according to International Standards Organization (ISO) 4049 specifications by using stainless steel split molds metal matrix, matrix with 4 mm in diameter and 12 mm deep can be separated (figure 1).Three of group are bulk fill flowble composite and one group with flowble composite (incremental fill composite)for comparison , all materials description found in table (1). group distribution as follow :

Group 1 : Universal Composite G-aenial Posterior GC - incremental composite. **Group 2** : Tetric Evo Ceram Bulk Fill composite . **Group 3:** Sonic Fill TM bulk-fill composite and **Group 4**: SureFil® SDR® Flow bulk-fill composite . The universal posterior composite GC sample were prepared incrementally. The bulk fill composite were prepared by injection the restorative material into the hole according to the manufacturer's directions for cavities deeper than ≥ 5 mm height and time of cured for 20 s by using a blue light-emitting diode with typical light intensity a 500mW/cm2 with wave length range 430-490 nm (LEDition , Ivoclar Vivadent , Germany) , The active tip of the light polymerizer was placed on the external surface in contact with the matrix hole , after setting the matrix open and the sample measured with caliper 5 mm in length and 4 mm in diameter (figure 2) samples stored in closed containers protected from light with aluminum sheet and kept at ambient temperature.

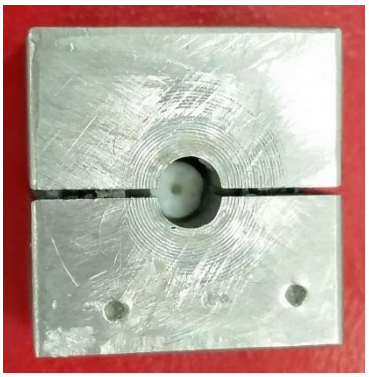

fig. 1; matrix metal

fig. 2 ; matrix

Table 1. The materials used in this study.

Brand Name	Manufacturer	Filler Volume (%) (wt)	Chemical composition
Sonic Fill TM A2 shade	Kerr Corp. USA/KAVO. Germany Lot. 5521812 Exp.2017-03	83.5%	Barium glass, silicon dioxide ,trimethoxysilylpropyl methacrylate(10-30 %),silicon dioxide(5-10 %),ethoxylated bisphenol A dimethacrylate (1-5%)bisphenol A bis(2-hydroxy-3-methacryloxypropyl)ether (1-5%) and triethylene glycol dimethacrylate(1-5%)
Tetric Evo Ceram Syringe refill Bulk Fill A2 shade	Ivoclar. Vivadent. AG. Liechtenstein Germany Lot. T32776 Exp.2018-07	79% -81%	Filler (79-81 % wt.);barium glass,ytterbium trifluoride, mixed oxide and prepolymer (78-81%)wt.,monomer matrix containing dimethacrylate (20-21%) Monomer matrix (20-21 % wt.); dimethacrylate additional contents (1%)
SureFil® SDR® Flow A2 shade	Dentsply. Konstanz. Germany Lot. 06021 Exp. 2016-06	68%	Barium-alumino-fluoro-borosilicate glass , strontium- alumino-fluoro-silicate glass , modified urethane dimethacrylate resin, ethoxylated bisphenol A dimethacylate (EBPADMA) , triethyleneglycol dimethacrylate (TEGDMA), camphoroquinone (CQ)photoinitiator , , photoaccel
Universal Composite G-aenial Posterior GC flow A2 shade	Tokyo. Japan Lot. 1408281 Exp. 2017-08	81%	Preplymerized filler ; silica,strontium and lanthanoid fluoride . inorganic ≥100 nm filler;fluoroaluminosilicate . inorganic filler≤ 100 nm fumed silica and methacrylate monomer (urethane dimethacrylate and di methacrylate co-monomer) .

2.2 degree of conversion

Samples tested are done in polymer research center in AL-Basra university by using Fourier transform infrared spectroscopy(JASCO FTIR 4200, Japan) to evaluate the degree of conversion (DC) each samples of composite milled into a fine powder with a mortar and pestle. fifty microgram of powder of sample was mixed with 5 mg of potassium bromide pressed to produce a thin disc and then placed in specimen holder and transferred to the spectrophotometer also unpolymerized specimen of each composite restoration were smeared onto thin potassium bromide discs, placed into a cell holder in spectrophotometer , and then a spectrum was obtained with same parameter as for the polymerized specimens. degree of conversion was measured by estimating the change in peak height ratio of the absorbance intensities of aliphatic C=C recorded at strong peak 1638 cm^{-1} and at weak peak 1608 cm^{-1} during polymerization . DC % was calculated according to the equation:

DC % = 100* {1- (R polymerized / R un polymerized) }

where R = band height at peak 1638 cm^{-1} / band height at peak 1608 cm^{-1}

2.3 Data analysis : All the available data were obtained the mean and standard deviation for each sample were collected and it analyzed with analysis of variance one-way ANOVA and LSD (less significant different) at p- value ≥ 0.05 level of confidence using utilizing SPSS statistical software (SPSS 15)

III. Results

The descriptive statistics of different group are presented in Table 2 . ANOVA test and LSD test are shown in table 3,4 which used to comparison for the effect of type of composite resin on degree of conversion . the result highly significant different between groups of bulk fill (Tetric EvoCeram flow , Sonic Fill & SDR) in comparison with incremental- Fill GC flow composite . comparison between different bulk fill composite showed highly significant different between Sonic fill and other types of bulk fill composite(Tetric EvoCeram and SDR) , while there no significant different between Tetric EvoCeram and SDR composite resin

Table 2; Descriptive statistics

Groups	N	Mean	S.D.	Min.	Max.
Posterior GC flow	10	55.52	3.75	51.2	62.03
Tetric EvoCeram	10	67.26	3.07	63	73.4
SonicFill	10	76.09	3.90	68.19	80.94
SDR	10	65.34	2.85	62.19	71.45

Table 3; ANOVA test

ANOVA	Sum of Squares	d.f.	Mean Square	F-test	p-value
Between Groups	2136.967	3	712.322	60.881	0.000 (HS)
Within Groups	421.206	36	11.700		
Total	2558.173	39			

Table 4 ; LSD test

Groups		Mean Difference	p-value
GC flow	TetricEvo Ceram	-11.74	0.000 (HS)
	Sonic Fill	-20.57	0.000 (HS)
	SDR	-9.82	0.000 (HS)
TetricEvo Ceram	Sonic Fill	-8.83	0.000 (HS)
	SDR	1.92	0.217 (NS)
Sonic Fill	SDR	10.75	0.000 (HS)

IV. Discussion :

Direct posterior restorations play a significant role in dentistry. But achieving predictable and successful outcomes remains a main concern for practitioners, due to technique sensitivity and the numerous steps required for proper placement. In addition Filling all of a tooth preparation with a composite at one time give several negative effects in resin-based composite restorations are frequently connected to polymerization shrinkage stress [23,24].

A new category of bulk-fill resin-based composites have been introduced, there are very few studies investigating the clinical and laboratory success of these materials [25,26,27,28]. The manufacturers claimed that bulk-fill materials can achieve a depth of cure of 5 mm.

Due to the complex mechanism of the polymerization reaction, the DC of Bis-GMA-based resin composites reported is between 45% and 85%.[29,30,31] To date, the minimum DC for a clinically satisfactory restoration has

not been precisely established. Nevertheless, a negative correlation of in vivo abrasive wear depth with DC has been found for values in the range of 55%-65%.[32]

in this study all types of bulk fill has higher percentage of degree of conversion in comparison with incremental composite , there is no research has the same brands of material but very little published research have different types of bulk fill agree with study like Irini et al., Y.A. Abed et al., Emily T. et al. and Acquaviva PA et al. [33,34,35,36] . this result because the materials has special properties that lead to more polymerization process that mention in the manufacturer's data ; Sonic-activated bulk-fill system (Sonicfill, Kerr Corp, USA/KaVo, Germany) produced with special modifiers of photoinitiators and uses refractive index matching in the composite material allow a full 5 mm depth of cure in 20 seconds .[37] and degree of conversion reach to 80% [38] while Surefill SDR (Dentsply. German) was marketed as dentin replacement a low-stress flowable base material that contains plymerization modulator,chemically embedded in the center of polymerizable resin backbone of the SDA monomer.the modulator has a high molecular weight. due to the confirmation flexibility around the center modulator impart [39]. also Tetric EvoCeram Bulk-fill (Ivoclar Vivadent AG, Liechtenstein) was introduced new germanium - based light initiator (Ivocerin),this initiator allows tetric EvoCeram Bulk fill to cure faster and deeper .ivocerin acts as a polymerization booster that offer greater reactivity to curing light as compared to champhorquinone and lucririn at depth up to 4mm [40] . in comparison between bulk-fill materials there is highly difference in DC % between Sonic fill and other types of bulk fill composite (Tetric EvoCeram and SDR) , this is due to chemical composition of inorganic resin of sonic fill composite that contain 3- trimethoxysilylpropyl methacrylate (10-30 %) , TEGDMA and BisEMA these types of monomer highly flexible , low- molecular weight , low viscosity all these properties lead to high mobility during polymerization and consequent favoring conversion [41,37]

V. Conclusions

compared to other composite types bulk-fill composite has good mechanical and physical properties with high degree of conversion means less side effect that cause from uncured resin (free monomer), also it can be concluded that sonic full composite with special designed unique activated - system (hand-piece with unidose - tip) is considered better bulk -fill composite material that used in posterior restoration

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